Evaluating the Potential of Using GIS for a Drained Wetlands Inventory

(7-County Metropolitian Area, Minnesota)

Conor Donnelly
Board of Water and Soil Resources
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Introduction

This report describes a project undertaken by the Minnesota Board of Water and Soil Resources to assess our ability to inventory potentially restorable wetlands in the seven county (Anoka, Carver, Dakota, Hennepin, Scott, Ramsey, and Washington) metropolitan area using readily available GIS data. By merging two geographic datasets, the County Digital Soil Survey (CSS) and the National Wetlands Inventory (NWI), we are able to generate maps representing potentially restorable wetlands. This method relies on the initial assumption that areas indicated as wetlands by NWI would largely coincide with hydric soils in the digital soil survey. Where hydric soils do not coincide with wetlands, a drained wetland might exist. Whether or not a drained wetland is restorable requires further inquiry. Possible uses of this inventory as well as its limitations and uncertainties are discussed.

The primary goal for this project was to investigate the availability and quality of geographic data necessary for a drained wetlands inventory. We intended to complete a countywide assessment of wetland status, rather than a site-specific evaluation. If local governmental units or others express sufficient interest in this project, further data collection would be needed to target specific sites for wetland restoration.

Methods

1) Required Materials/Data Acquisition

Digital Soil Surveys

County soils coverages were obtained in Arc export format through the Metro GIS Data Finder web site (http://www.datafinder.org). These layers were digitized from published soil surveys which are distributed by the Metropolitan Council free of charge. The quality and

completeness of the soils layer varies from county to county. This will be discussed further in the accuracy and limitations section.

The Map Unit Interpretations Database (MUIR) was used to determine which soils in the county survey should be considered hydric. MUIR data is a collection of soil and soil-related properties, interpretations, and performance data for a soil survey area and its map units, map unit components, and component layers. For the purposes of this project we needed to determine for each mapping unit whether or not it is hydric. A hydric soil is defined as: "*a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part"* (USDA/NRCS, 1998). The percentage of hydric components for each soil series was taken into consideration for our analysis. For this analysis, a map unit was only considered hydric if it consists of at least 75% hydric components. Two tables in the MUIR database (COMP and HYDCOMP) were used to make this determination. The HYDCOMP table lists all map units in a soil survey area that contain hydric components. The COMP table gives the percentage of each component within a map unit (http://www.statlab.iastate.edu/soils/muir/).

National Wetlands Inventory

The National Wetlands Inventory (NWI) project was undertaken by the U.S. Fish and Wildlife Service to generate information about characteristics and extent of wetland and deepwater habitats in the United States. The Minnesota Department of Natural Resources provides these data free of charge through their (data deli) web site. The USFWS used high altitude color-infrared and black and white photography at scales of 1:58000 to 1:80000 in stereo pairs for photo-interpretation of wetlands. Collecting all the quadrangles within the county,

merging and clipping provided us with a seamless countywide coverage (http://deli.dnr.state.mn.us).

2) Data Preparation

The NWI map features were reselected to eliminate those areas considered upland. Any area mapped as Lacustrine, Palustrine, or Riverine were included and considered wetlands.

Digital soils coverages generally required more processing than NWI data. The county soil surveys for the metro area vary greatly in quality and suitability for mapping. Some counties use modern soil taxonomy and others use outdated taxonomy. Some counties have soil line work delineated onto an ortho-rectified photobase and others were delineated on a rectified (non-ortho) base. In some cases, attributes and/or lines in the digital database are missing, or the countywide coverage is not complete. In these cases, cross-checking the digital layer with the hard copy soil survey maps and updating polygons with appropriate values was required. In other cases, the soil line work was not seamless across the county, so digital processing was used to fill in the gaps with properties of adjacent soil types (see Appendix #1).

Once attribute information and line work is complete, reselecting is used to choose only those soil-mapping units considered hydric by a minimum 75% hydric components criteria. Because of the variability in county soil survey status, the quality of the survey used has a direct impact on the positional accuracy and attribute accuracy of this drained wetlands inventory. For an updated list of county soil survey status, see: http://www.lmic.state.mn.us/chouse/soilstat.htm

3) Union of Soils and NWI

After soils data and NWI were adequately prepared for use in this analysis, features of the two layers were joined using the UNION command in Arc Info GIS. The resulting layer contained all the features and attributes of both layers. Examining this unioned layer reveals where hydric soils and NWI polygons overlap and where they do not. (Fig. 1) The next step involves determining which combinations of NWI and soils polygons reveal a potentially restorable wetland.

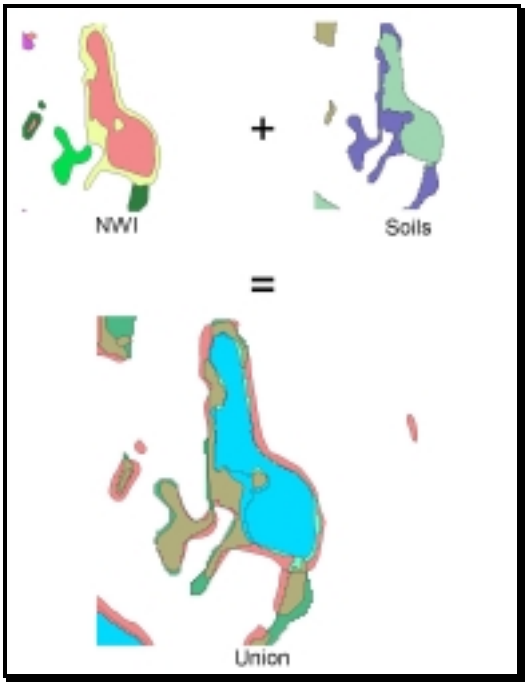

Figure 1

Classification of Merged Features

Five classifications were determined to be relevant for this inventory of drained wetlands.

1) Soil map unit mostly not hydric, but is included in NWI.

These areas are included in the NWI but do not meet our criteria for hydric soils. This situation could arise for two reasons. Perhaps a particularly wet year was used for photo interpretation of NWI, so extent of wetlands could be exaggerated. Or, perhaps the associated soil mapping unit contains less than 75% hydric components, so it was considered not hydric. However, it may in fact be hydric in certain locations.

2) "W" soil and included in NWI, but not as type "L1" (OPEN WATER WETLAND).

These areas appear in the soil survey listed as "W" soils. This means that the mapped area contained open water when the soil survey was completed, so a particular soil type was not defined. These areas also exist as wetlands in the NWI layer, but are NOT included in the subsystem Limnetic, which are all deepwater habitats in the Lacustrine system.

3) Map unit is mostly hydric, not an open water "W" soil, also included in NWI, but not type "L1" (WETLAND).

These areas indicate a strong positive correlation between the soil survey and the NWI. Soil survey indicates that the map unit is greater than 75% hydric components and the NWI indicates that the area is a wetland, but not deepwater (< 2 meters).

4) Hydric Soil, but not included in NWI (POTENTIALLY RESTORABLE WETLAND).

This classification represents areas that are most likely drained and potentially restorable. The soil survey indicates the map unit consists of more than 75% hydric components, but the area is not included in NWI at all.

5) Hydric soil, or "W" soil and included in NWI as type "L1" (DEEP WATER).

This class represents NWI deep water lakes, (> 2 meters) and soil survey lists the area as "W."

Data queries were performed on the attribute table of the unioned soils and NWI layers in order to generate this classification. The resulting maps for each of the seven metro counties are included in appendix 3.

Accuracy and Limitations

In order to assess the accuracy of these data, one must consider both positional and attribute accuracy of the digital soil surveys and the NWI data. The status of the county soil surveys introduces most of the uncertainty to this drained wetland inventory. Three of the seven metro counties currently have outdated soil surveys compiled on rectified (non-ortho) base photography. These surveys also have outdated soil taxonomy that might affect attribute accuracy; the positional accuracy is diminished in those areas of greatest topographic relief. Anoka, Carver, and Scott counties are in this group of status "3" counties. Dakota, Hennepin, Ramsey and Washington are considered status "2" counties. These counties have soil surveys that utilize modern soil taxonomy and have soil maps compiled on rectified photography. Attribute information has a greater tendency to be correct, however, spatial accuracy still varies with topography. (For a more complete discussion of Minnesota county soil surveys, see County Soil Surveys: Guidelines for Digitizing, Minnesota Governor's Council of Geographic Information, 1997. http://www.mnplan.state.mn.us/press/soilsrpt.html)

Although NWI maps exist in seamless and complete countywide layers, they, too, have limitations. NWI maps do not claim to depict all wetlands. In general, the smallest units mapped are from one to three acres, depending on the wetland type and quality of the photography. Wetlands in forested landscapes may be underestimated due to vegetative cover obscuring the photo interpretation. Some areas were derived from black and white aerial photography and may represent a more conservative estimate of wetland extent, perhaps leaving out wet meadows.

Another aspect of NWI data to take into consideration is the effect of annual precipitation on photo interpretation. If the photograph was obtained during a wetter or drier than average year, the extent of wetlands could be exaggerated or diminished. Finally, the NWI deliberately omitted mapping wetlands that appeared to be cropped as indicated on the aerial photography. For these reasons, it is important to be aware of the photo dates used for NWI interpretation. All photography used in for NWI in Minnesota was taken between 1974 and 1984.

Other Examples of Drained Wetlands Inventories

In 1999, the Hennepin Conservation District (HCD) initiated an extensive effort to produce a wetland inventory that included drained and altered wetlands. This project required a great deal of data collection and photo interpretation. In addition to soils survey and NWI data, the HCD used rainfall data from the past 15 years to determine for each year whether normal precipitation (within 30% of the thirty-year average) was present. Infrared (IR) stereo photos taken in 1994 and Metro Mosquito Control District maps were also used. In order to prepare for this analysis, a GIS basemap was created showing ortho photos, section lines, and parcel lines.

Six classifications were used for wetlands in the HCD inventory.

1) D/C (Dry Cropped) – the site is cropped and cannot be distinguished from the surrounding crop.
2) D/NC (Dry No Crop) – the site is not cropped and cannot be distinguished from the surrounding vegetation.
3) W/CS (Wet, Crop Stress) – the site is cropped and the crops are discolored due to water stress.
4) W/NC (Wet, No Crop) – the site is not cropped and appears to have wetland hydrology.
5) W/DO (Wet, Drowned Out) – the site is surrounded by cropland and crops on the site appear to have died due to standing water.
6) Ponding – ponded water is visible on the site.

Decision matrices were used for cropped and non-cropped wetlands to determine if a site is a drained, partially drained, or existing wetland. Field verification is required if certain criteria are not met. If a wetland polygon is indicated with hydric soils, but ≤30% of normal precipitation years show wetland hydrology, field verification is needed. If hydric soils are not present and ≤50% of normal years show wetland hydrology, field verification is required.

This study takes into consideration some non-geographic variables in assessing restoration potential, in particular, the number of landowners associated with a drained wetland. If a wetland appears drained and has two or fewer landowners, restoration potential is considered excellent. If wetland appears drained and has more than two landowners, restoration potential is considered good. Also, if the wetland does not appear to be drained, restoration potential is considered poor.

The site specific analysis done by the Hennepin Conservation District is a good example of what could be done by local governmental units or others interested in exploring the layers generated by this BWSR inventory. Contact Dave Thill at Hennepin Conservation District for more details (dave@hcd.hennepin.mn.us).

Kara Dunning, a graduate student at the University of Minnesota, completed a converted wetlands inventory in 1997 for three study sites in Kittson, Cottonwood, and Chisago counties. This inventory used a methodology similar to that used in our analysis. Dunning's technique goes one step further by including a comprehensive layer representing artificial drainage by private ditches and drainage tiles. This layer was generated through aerial photo interpretation and ground surveying. Dunning then collected data for the depth of each ditch and used the lateral-effect formula to calculate the area effectively drained. This data was used to generate a

buffer around the ditches that represents an area classified as “extremely likely converted wetland.”

Dunning’s inventory produces an ordinal classification, from “extremely likely converted wetland” to “unlikely converted wetland” (Fig. 2). If a layer showing artificial drainage ditches and tiles was available in metro area counties, analysis could be carried out using the data and processes used in this analysis as a starting point.

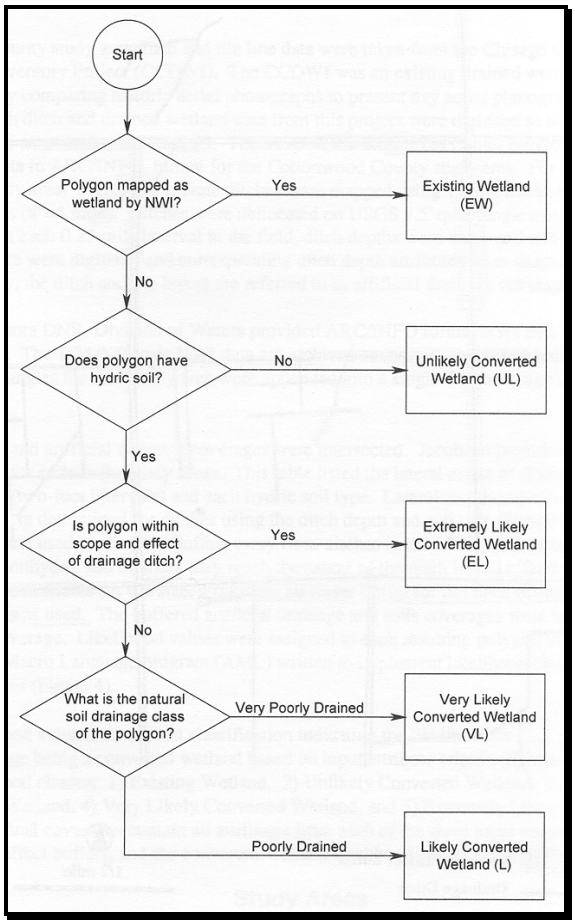

Figure 2 Source: (Dunning and Queen, 1997)

Recommendations for Further Inquiry

1) The 1997 Land Use/Land Cover layer for the metro area is available for download from the Metropolitan Council. These data could be useful for masking out areas of the county that are not realistic candidates for restoration due to current land uses. Areas already developed for residential, commercial, industrial, or roads might be masked out of the drained wetlands inventory in order to focus restoration efforts on other parts of the county.

2) MUSA line – The Metropolitan Urban Service Area, defined by the Met Council for regional planning efforts, could be used as a rough guideline for focus of restoration efforts outside the MUSA. This layer is also readily available from the Metropolitan Council.

3) Digital Elevation Model – Shaded Relief Topography. It might be useful for some purposes to superimpose the drained wetlands inventory over a semi-transparent shaded relief Digital Elevation Model, (DEM). This would help give a visual cue to those areas that are more depressional and those that are upland.

4) Countywide parcel data exists for all seven metro area counties. These data could be used in conjunction with the BWSR drained wetlands inventory in order to identify potentially restorable wetlands with the fewest number of landowners. These wetlands might be identified to have high realistic restoration potential.

Summary

Our goal for this project was to evaluate the potential for using GIS to facilitate a countywide assessment of drained wetlands in the seven county metro area. This involved assessing the availability, completeness, and accuracy of soils and wetlands data. Gathering data and preparing it for use within the GIS environment proved to be the most time consuming aspect of this project. Availability, quality, and completeness of digital soils data vary greatly among the metro area counties. National Wetlands Inventory data is readily available across the state and requires little effort for preparation and use. By unioning the features of these two datasets, we were able to summarize the number of acres within each county that appear to be "potentially restorable" (see Appendix #2). This information could be useful for countywide planning and assessment of water and soil resources; however, using these data for site specific project planning is not recommended without additional onsite fieldwork.

Appendix

1) County Soils Survey layers that are not seamless required some extra steps in data preparation that are explained here (Fig. 3). Fixing these seams required the vector polygons existing as ArcInfo coverages to be converted to the GRID format using the POLYGRID command. Next, the GRID file is exported to a geoTIFF image using the GRIDIMAGE command. The TIFF file is imported into EPPL. The EPPL command FILL is now used to extend the values of adjacent polygons into the seam areas of missing data. Once the fill is completed, the conversions are reversed to bring the file back into vector data as an ArcInfo coverage.

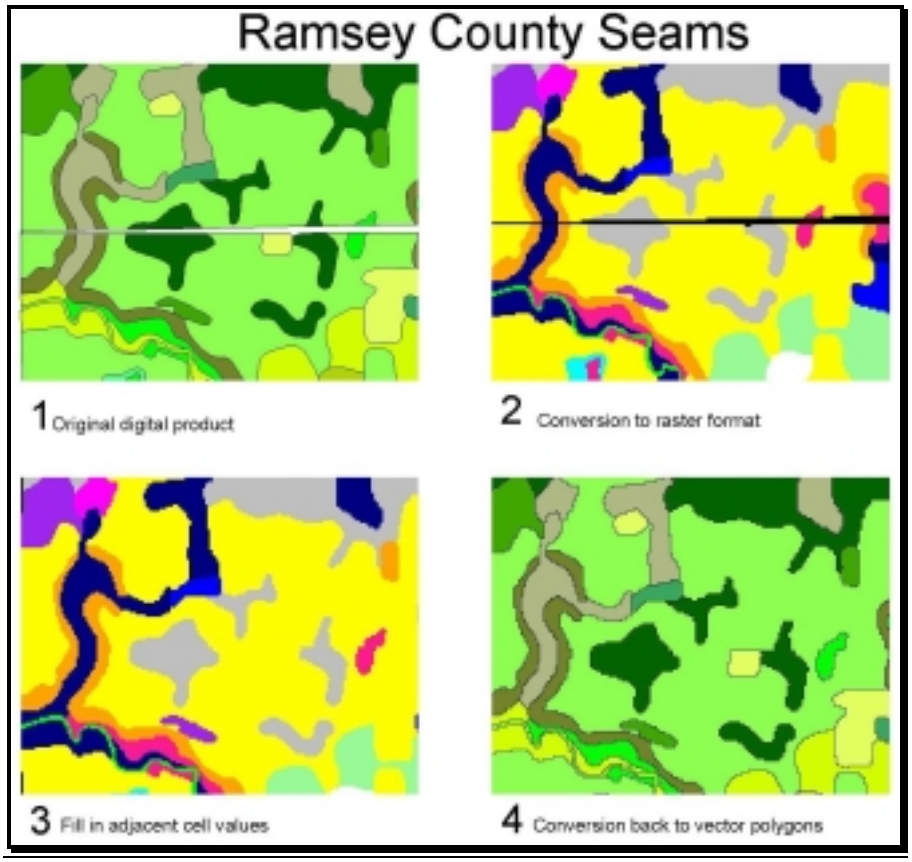

Figure 3

It should be noted that this method of filling in seams DOES NOT improve data quality, accuracy or completeness. It simply makes the data appear more complete and suits our needs here for a countywide assessment of potentially restorable wetlands. For site specific analysis, these data may not be appropriate without additional onsite fieldwork.

2) Acreage Totals by County

	Anoka	Carver	Dakota	Hennepin	Scott	Ramsey	Washington
Non-hydric, in NWI	22,393	6,217	7,308	26,074	15,542	4,316	9,588
Open Water Wetland	4,036	4,560	3,778	4,870	3,165	2,428	4,904
Wetland	55,109	27,229	16,425	24,204	19,333	4,926	12,789
Potentially Restorable Wetland	38,638	61,281	34,862	48,715	30,492	3,695	16,733
Deep Water, >2 meters	7,935	7,298	6,951	22,212	4,343	7,703	17,665
Total County Area	285,137	240,512	374,985	388,070	338,310	108,716	270,730

See page six for a definition of these five classifications.

3) Summary of Map Units considered hydric in this analysis.

Anoka

Map Unit	Acres
Bm	1,914
Cb	759
Du	866
Gc	440
Is	1,130
Iw	23,615
Kr	1,406
Lx	363
Ma	10,966
Mk	1,654
No	1,594
Rf	39,020
Rg	772
Rh	1,360
Ru	171
Se	4,291
Wb	1,553

Carver

Map Unit	Acres
BH	1,130
BY	1,507
CL	293
CO	7,570
CS	1,528
CT	6,809
CU	1,016
CW	19,490
EX	2,112
GL	6,772
HM	10,456
MK	16,033
MP	3,005
MY	908
OS	413
PM	7,701
PS	624
TT	822

Dakota

Map Unit	Acres
109	1,468
113	2,155
114	1,767
176	2,839
1816	1,643
1821	1,560
1824	867
1825C	218
189	922
208	2,829
226	446
252	9,140
253	2,166
255	2,896
317	473
318	978
344	2,129
378	3,593
408	736
414	757
465	1,566
522	373
539	2,392
540	3,349
545	481
98	3,876

Hennepin

Map Unit	Acres
1007	98
1055	128
540	487
83	133
850	28
Bc	715
Bd	199
Ca	225
Co	15,198
Dm	796
Du	3,640
Gc	9,353
Ha	17,472
Is	3,768
It	962
Iv	314
Mt	1,449
Pa	12,928
Pb	780
Pm	4,062
Sh	281

Ramsey

Map Unit	Acres
113	25
123	470
161	659
170	271
1847	28
189	152
266	194
325	97
408	14
456	707
481	76
540	2,423
541	1,953
543	541
544	379
552	272
75	381

Scott

Map Unit	Acres
Bc	1,207
Cc	1,533
De	266
Df	919
Fa	1,189
Ga	7,969
Ia	366
Oa	580
PaA	3,824
PbA	13,383
Ra	923
Wb	17,785

Washington

Map Unit	Acres
113	822
123	4,558
161	1,238
170	1,027
1847	1,044
189	862
266	3,050
325	754
408	472
456	524
468	401
481	454
540	3,388
541	4,830
543	924
544	2,785
75	2,533

4) County GIS maps

a. Anoka County
b. Carver County
c. Dakota County
d. Hennepin County
e. Ramsey County
f. Scott County
g. Washington County

These maps represent the final product of this drained wetlands inventory using the methods described. Please contact me via email for more information about this report at conor.donnelly@bwsr.state.mn.us, or see our web site at www.bwsr.state.mn.us.

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